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Research Article

Production and Characterization of Breadfruit (*Artocarpus altilis*) Bread Flour

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ABSTRACT

Background and Objective: The breadfruit, a plant native to Indonesia, is endangered in Benin due to limited data on its use. The general objective of this study was to characterize the flour of breadfruit and its suitability for use in bread formulas. **Materials and Methods:** Physico-chemical analysis of breadfruit flour was carried out. Water, ash, protein and fiber contents of breadfruit flour was determined. The breadfruit flours were used to make formulations first with wheat flour only and secondly with wheat flour and cassava flour. The flour mixtures were characterized and used in the production of French-type bread. **Results:** The flour of the breadfruit contains on average 2.487% proteins, 2.875% ash and 3.01% fibers. Its water content is 3.18%. Of all the formulations (10, 15, 20, 25 and 30%) made with the flour of the breadfruit, only the formulation with 10% of the flour of the breadfruit gave a better bread and more appreciated by the panelists. In the formulations in which cassava flour and breadfruit flour was used in the same proportions, only bread with 10% of the cassava flour and breadfruit flour was little appreciated by the panellists. **Conclusion:** The formulation made with 10% of the breadfruit and wheat flour was the most suitable.

Key words: Benin, breadfruit, bread-making, cassava roots, food formulations, wheat flour

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Native to Polynesia and Indonesia, the breadfruit (*Artocarpus altilis*) has been introduced to Benin from the West Indies since the days of slavery[1,2]. The Departments of Ouémé and Plateau constitute the areas of high production[2]. The fruit is abundantly available for a short period of time and is difficult to keep fresh over a long period[3]. Several studies have shown that nearly 50% of the fruit is lost after harvest[2,4]. It is included in the list of underutilized foods[5]. There is no doubt that the name breadfruit comes from its ability to transform into bread products. Indeed, the fruit would then have the ability to be used for bread-making[6]. A number of studies have been completed on the development of composite flour in which a part of wheat flour is replaced by other starchy sources in order to increase the value of breadfruit[7-9]. Many varieties of maize, sorghum and tubers have been reported to be suitable for breadmaking[10]. Dioscorea rotundata, a variety of yam that has a starch content of 20-25% and responds well to milling, is used in Nigeria to make flour for bread[11]. In Cameroon, the flour from the cassava variety IRA 8006 is used for bread making with a dry matter content of 35%[12]. Once the bread flour is obtained, there are several methods of making bread and other good quality pastry products. Several derived products have been obtained from bread-making compound flours obtained from roots and tubers and from cereals. For example, English type sandwich breads are made from sweet potato, cassava, sorghum and maize and French type breads, traditional donuts and pancakes are made from maize, sorghum and cassava, as well as pastries are obtained from these compound flours[13]. In general, it has been found that a flour is non-breadmaking when it does not contain gluten, a component that makes the dough "rise"[14]. Compound flours (also known as substitution) come either from tubers or roots (cassava, yam, potato, sweet potato), or from legume protein concentrate (soybean, cowpea), or from cereals (maize, sorghum, etc.) are suitable for making breads, cookies, pasta, various cakes[15]. To some extent, breadfruit flour can be used to produce formulations derived from cereal, root and tuber flours containing a small amount of wheat flour for the manufacture of various derived products, such as cakes, pancakes and English and French bread[16]. As in most developing countries, products derived from wheat flour play a very important role in human food in Benin. However, these products are becoming more and more difficult to obtain as their prices keep increasing. For example, the price of bread, which was 60 FCFA in 1996, rose in 2017 to 125 FCFA or even 150 FCFA in certain localities of the country[17]. Increasing prices of these products are primarily due to unavailability of local wheat. As the wheat is not produced at home in Benin, it is imported. The slightest disruption in world production or an increase in oil prices have a direct impact on wheat flour prices. In 2008-2009, the situation became even more alarming due to increasing wheat prices during the economic crisis. The purpose of this study was to make other bread-making flours available from Benin-grown food products. The general objective of the study was to enhance the use of breadfruit by using its flour in bread formulas.

MATERIALS AND METHODS

The material used consisted mainly of breadfruit, cassava roots and wheat flour. Breadfruit was purchased from the Communes of Dangbo and Avrankou. They were transported in jute bags by car and motorcycles. The fruits were spread out on the ground and were processed the next day. As for the cassava roots, they were bought in Houèdo from the commune of Abomey-Calavi. The transport was done in jute bags and by means of motorcycles. The sweet variety was the one used for this production. Processing of cassava roots took place on harvest day. Finally, as for the wheat flour, it had been bought in Akassato from the commune of Abomey-Calavi on the day of the production of the breads.

Production of breadfruit and cassava flour: The breadfruit flour was produced using the production technology described by Turi *et al.*[2]. The different stages of this production are summarized in the diagram illustrated in Fig. 1. As for cassava flour, the production technology used is that developed by CORAF/WECARD[19]. Figure 2 illustrates the technological diagram of cassava flour production.

Formulation tests: Table 1 and 2 summarize the formulations based on flours obtained. Previous studies conducted by Turi[2] and Olatunji and Akinrele[19] on breadfruit flour led to the

Table 1: First series of formulation tests

Types of flour	Incorporation rate (%)				
Breadfruit flour	10	15	20	25	30
Wheat flour	90	85	80	75	70

Table 2: Second series of formulation tests

Types of flour	Incorporation rate (%)				
Breadfruit flour	10	15	20	25	30
Cassava flour	10	15	20	25	30
Wheat flour	80	70	60	50	40

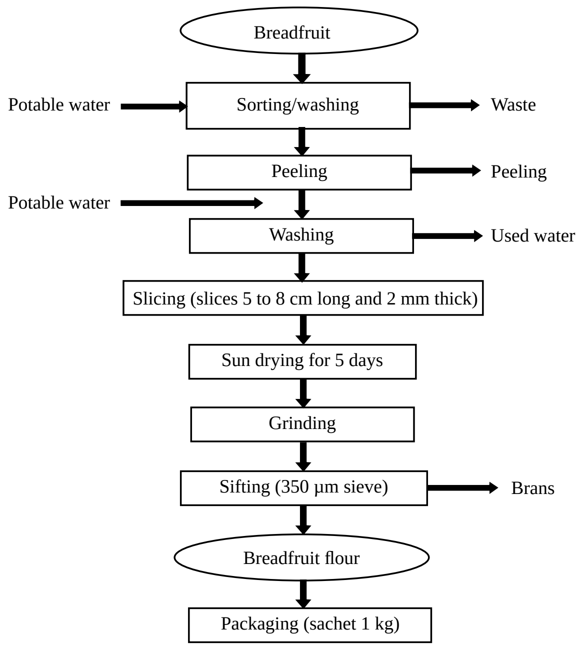


Fig. 1: Technological diagram of breadfruit flour production

development of these formulations. Likewise, they were based on the standards and regulations of mixed breadmaking in Benin (Decree No. 2008-571).

Evaluation of the physico-chemical characteristics of flours

Determination of the water content: Water content was determined according to the AOAC method[20].

Determination of protein content: The total protein content was determined by the AOAC method[20]. It was calculated using the conversion factor 6.25[20]. The results were expressed as an average of three trials.

Determination of ash content: The crude ash content of flour was determined according to the AOAC method[20].

Determination of the dietary fiber content: In a ground-neck Erlenmeyer flask, one gram (W1) of the sample was added to 200 mL of 1.25% H_2SO_4 previously heated and slightly cooled (around 80-85°C) and a few drops of antifoam. Heat this mixture slowly to reflux, after 30 min from the start of boiling, then filter under vacuum through a round filter paper placed in a Büchner. Rinse the filter paper with 200 mL of 1.25% NAOH previously heated in a cooled Erlenmeyer flask (around 80-85° C). Heat this mixture slowly to reflux, after 30 min from the start of boiling, then transfer all the insoluble matters into a target raw meal by filtering the contents of the Erlenmeyer flask using a vacuum pump. Rinse the contents of the target raw meal successively with boiling water then 1% HCl then with boiling water, then rinse twice with ethanol and then three times with acetone. Dry the target raw wines in an oven at 105°C for 1 hr, let them cool and weigh (W2). Incinerated in an oven at 550°C for 1 hr then cooled and weighed (W3):

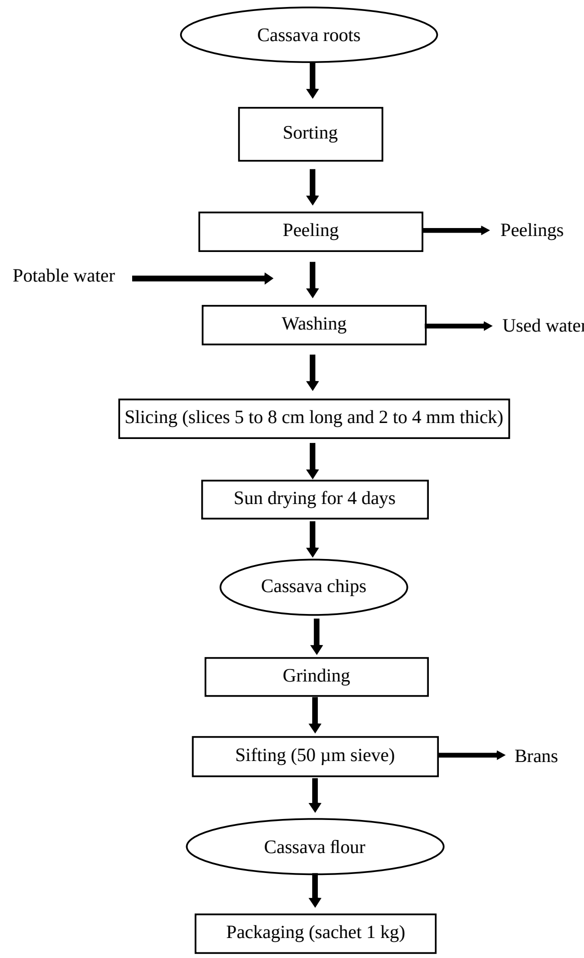


Fig. 2: Technological diagram of cassava flour production

$$\text{Crude fiber (\%)} = \frac{W2\text{-}W3}{W1}$$

Bread production: The bread was produced according to the technological production diagram used in the Agro-technical center. This production diagram is illustrated in Fig. 3.

Evaluation of the organoleptic characteristics of the breads produced: The breads produced were tasted by a panel made up of 30 tasters following a 5-level hedonic test (appendix). Each loaf was assessed for color, swelling, taste,

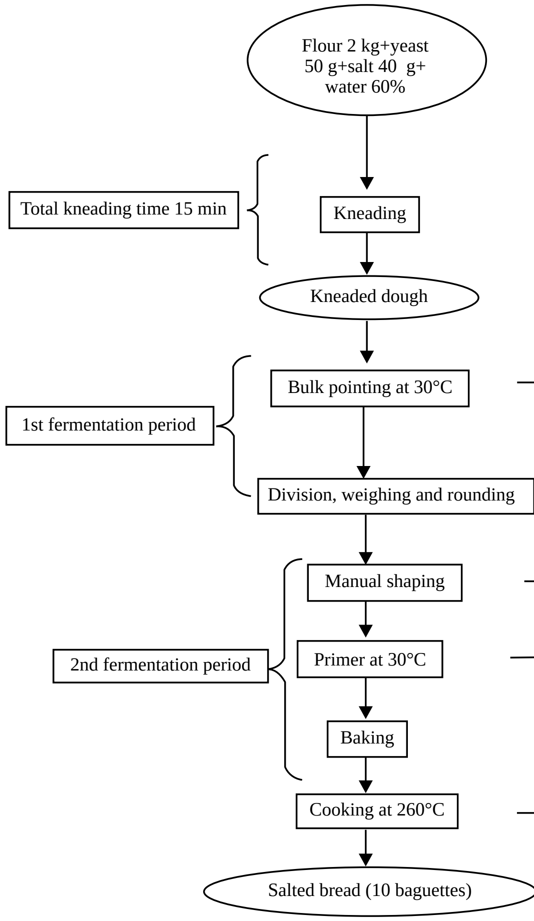


Fig. 3: Technological diagram of salted bread production

odor and overall acceptability at levels pleasant, somewhat pleasant, neither pleasant nor unpleasant, somewhat unpleasant and unpleasant. The tasters were chosen at random and trained for the occasion. The order in which the breads were presented to the tasters varied from person to person. The data after tasting was processed in software R. The database was established using the Excel spreadsheet.

RESULTS

Breadfruit flour: The dried strips of breadfruit yielded two different colored flours. In the first day of processing, white flour is made from fruits that have reached their maturity cycle and have been dried for at least seven hours. A brown flour was produced by fruits that did not undergo this drying rate and did not reach maturity.

Physicochemical characteristics of the flours produced: In Table 3, the physicochemical characteristics of cassava flour and breadfruit are presented.

Table 3 shows that breadfruit flour has a higher protein and ash content than cassava flour by over two times. Likewise, fiber content is almost twice that of cassava. On the other hand, cassava flour is almost 1.5 times wetter than that of breadfruit.

Bread production: The flours developed were used in the production of French breads. In the first substitution, 25 and 30% of the flour of the breadfruit were added respectively to 75 and 70% of the wheat flour and a hard porous dough was obtained, whose tenderness was lower than that obtained with 100% of the wheat flour. The breads made from these formulations could not be presented to the tasters because of their textures. Likewise, in the second substitution, a mixture of 20, 25 and 30% cassava flour with 60%, 50% and 40% wheat flour yielded a hard dough with less extendibility than ordinary bread (100% wheat). A mixture of 10% (F1), 15% (F2) and 20% (F3) of the breadfruit flour with respectively 90, 85 and 80% of the wheat flour gave breads with similar

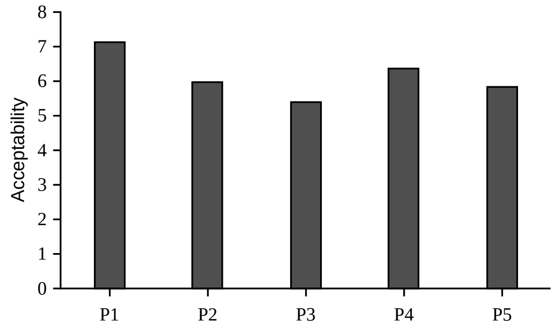
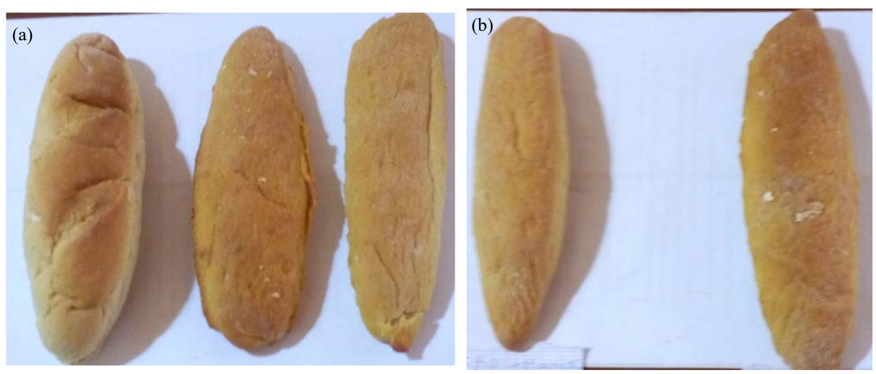


Fig. 4: Overall acceptability of breads



Photos 1(a-b): Images of breads P1, P2, P3, P4 and P5

Table 3: Physicochemical characteristics of cassava flour and breadfruit

Parameters/Products	Protein content (%)	Ash content (%)	Moisture (%)	Fiber (%)	Particle size in μm
Breadfruit flour	2.487	2.8751	3.18	3.01	350
Cassava flour	0.964	1.3538	4.552	1.64	350

Table 4: Correlations between principal components and variables

	Component 1		Component 2	
Variables	Correlations	p-value	Correlations	p-value
Fiber	0.97	0.005	-	-
Ash	0.92	0.025	-	-
Acceptability	-0.99	0.001	-	-
Swelling	-0.99	0.001	-	-
Taste	-	-	0.95	0.014
Moisture	-	-	-0.26	0.010
Color	0.86	0.001	-	-
Odor	-	-	0.74	0.001
Protein content	-	-	-0.83	0.001

characteristics to ordinary breads after kneading in the first substitution. At the level of the second substitution, the breads obtained from the F4 and F5 flours had characteristics similar to those of ordinary bread.

Organoleptic characteristics of breads: Using a tasting sheet, the breads obtained from F1, F2, F3, F4 and F5 flour were presented to the tasters for assessment. Analysis of the data from this tasting gave the following results.

Figure 4 illustrates the overall acceptability of breads P1, P2, P3, P4 and P5 made from respectively F1, F2, F3, F4 and F5 flours.

Figure 4 shows that P1 bread is the one most appreciated by tasters. P4 bread is second followed by P2, P5 and P3 breads respectively. The photo illustrates the images of breads P1, P2, P3, P4 and P5. The Principal Component Analysis (PCA) was carried out on the tasting data (Photo 1). Table 4 and Fig. 5 shows the correlation between principal

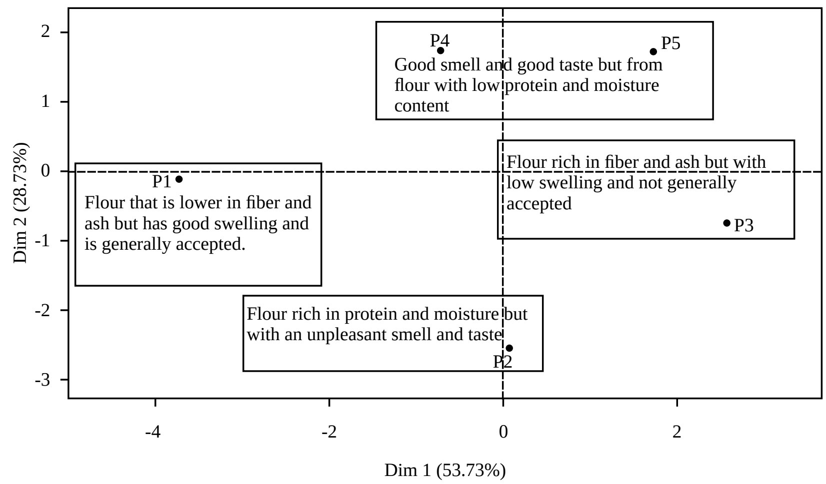


Fig. 5: Characteristics of the flours used in the production of each bread

components and variables and the physicochemical characteristics of the flours from which the breads were derived.

Table 4 shows that the two principal components are sufficient to guarantee the reliability of the results because they contain 95.75% of the information. Figure 5 shows that the overall popular bread (P1) with good swelling is obtained from a flour having low fiber and ash content. On the other hand, P3 bread with a high protein and fiber content does not have good swelling but a more appreciated color. P4 and P5 breads have a pleasant smell and taste and are made from a low protein flour. On the other hand, P2 bread made from flour rich in protein and with a high humidity rate has an odor and a taste that is not appreciated by tasters. Protein content can therefore affect the elasticity of pasta, as well as the taste and smell of the finished product (bread).

DISCUSSION

The flours produced from the breadfruit have changed color. This change in color is due to the ripeness of the fruits. Similar results were reported by Turi *et al.*[2] who also obtained a white flour and a gray one. He concluded that the color change is related to the ripeness stage of the processed fruit. But this change in color may be related to the non-enzymatic browning that occurred during drying, because the fruits which had reached maturity and whose lamellae were well dried did not change color. Solar drying is therefore not suitable for transforming this fruit into flour. Olatunji and Akinrele[19] reported that pasta with the addition of 22-30% breadfruit flour was more porous. In this case, the fermentation cannot be prolonged because the gas production is low and/or the entrapment of the gases was less efficient. In these studies, the results obtained with 25% and 30% breadfruit flour are confirmed. As a result of the low protein content of these flours, this observation is logical, since gluten, which contributes to the puffiness and tenderness of pasta, is contained in proteins. French bread flour must contain less than 1% fiber and an ash content between 0.60 and 0.62 according to the International Standard. The values obtained for F1 flour are slightly higher than the standard values. However, F1 flour has the lowest fiber and ash content out of all the formulations. According to Olatunji and Akinrele[19], 11% addition of breadfruit flour was the best formulation. This confirms the tasters appreciation of bread with 10% of the breadfruit flour. The results obtained for P3 bread are similar to those of Nochera and Caldwell[18] who had worked on breadfruit flour and concluded that 20% substitution of wheat flour by fruit flour bread is acceptable in terms of color for both breads and cookies. From this result, it appears that a flour with a high fiber and ash content cannot produce a well-puffed bread but rather a bread with good color. In general, we find that as the flour content of breadfruit increases, the tenderness of the pasta decreases. This could be due to the low protein content of the breadfruit flour. Likewise, we find that the addition of cassava flour failed to improve this weakness. Indeed, cassava flour contains only 0.964% protein; which is much lower than the protein content of breadfruit. However, to overcome this weakness, you need a flour with a higher protein content or an improver that could compensate for the protein deficit. Similar opinion was expressed by Olatunji and Akinrele[19] who reported that the amount of gluten as well as the pH decreased when breadfruit flour was substituted for wheat flour, resulting in a reduction of dough development time. They also observed sagging of the dough. Furthermore, they also found that adding breadfruit flour to the dough proportionally increased its resistance to stretching and decreased its stretchability. They explained their results by the fact that the gluten strands were not strong enough to withstand the large production of gas required for a good dough to expand; hence, the loaves collapse. They concluded that the bread is palatable and qualitatively acceptable for a 10% substitution rate of wheat flour by breadfruit flour[19].

CONCLUSION

Breadfruit flour can be used for bread production. The breadfruit flour was incorporated into wheat flour in the proportions of 10, 15, 20, 25 and 30%, only 10% remains the best. In the second substitution, cassava flour was added to the first substitution in the same proportions, only breads with 10 and 15% of breadfruit and cassava flour gave bread similar to regular bread (100% wheat). Overall, these breads were less appreciated than bread made with 10% breadfruit flour. The bread with 10% breadfruit flour is appreciated because of its greater swelling than the other two which are more appreciated in relation to taste and smell.

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